THE QUALITY OF WATER AND CONFIRMATORY TESTS FOR B. COLI[1]

By Abel Wolman

The reliability of the presumptive test as an index of the presence of B. coli in water in the light of recent investigation, has been seriously questioned. The United States Hygienic Laboratory in its Potomac River report finds that the presumptive test varies in its importance as a measure of pollution, with the degree of pollution itself. Dr. Frost, in the Ohio River investigation,[2] concludes that the error in the presumptive test is greatest in the examination of treated waters. A. H. Creel[3] and Edward Bartow,[4] working on waters of similar character, that is, on drinking water from railroad trains, obtained results entirely at variance. The former, for instance, confirmed only 21 per cent of positive tests for gas formation, while the latter isolated B. coli in 83 per cent of the tubes showing gas formation. Graf and Nolte[5] conclude, on the other hand, that the bile test is a better index of the presence of B. coli the more polluted the water.

The author, having at hand analyses of various types of waters in the State of Maryland, made during periods in 1915 and 1916, thought it would be of interest to tabulate the results obtained in colon determinations and to attempt to draw possible conclusions regarding the efficacy of presumptive tests as an index of the presence of B. coli. In Table 1 the results for the raw waters and plant effluents of three filtration plants have been tabulated. The raw waters of all three are from surface streams, the pollution of the watersheds of each varying in intensity according to the rating given in the table. This rating has been based upon a knowledge of sanitary conditions resulting from a study of the three watersheds. It is of striking interest to note that the percentage of tubes con-

[1] Read before the Richmond Convention, May, 1917.

[2] *American Journal of Public Health,* Vol. VI, No. 6, June, 1916.

[3] *Hygienic Laboratory Bulletin No. 100,* pp. 43–57.

[4] *Journal of the American Water Works Association,* Vol. 2, No. 1.

[5] *American Journal of Public Health,* Vol. VI, No. 10, October, 1916.

firmed arrange themselves in the same grouping, A, B, C, as the sanitary survey of the streams, in a qualitative manner only, had already indicated. If we were to attempt to rate these raw waters by presumptive tests alone, it is at once obvious that the arrangement would be different and apparently not as accurate, since a study of the isolation tests indicates that the measure of the pollution of the streams varies in the same way as determined upon by the percentage of tubes confirmed. In the effluent samples from these same plants, the order of decreasing purity, as determined by presumptive tests, is C, A, B; by isolation tests, A, C, B, and by percentage of tubes confirmed, A, B, C. Assuming that isolation

TABLE 1

Raw water and effluents of three filtration plants

	RATING	NUMBER OF SAMPLES	PER CENT OF SAMPLES Positive Presumptive		PER CENT OF SAMPLES Positive Isolation		TOTAL NUMBER OF TUBES SHOWING GAS	PER CENT OF TUBES CONFIRMED
			10 cc.	1 cc.	10 cc.	1 cc.		
Raw water	A	56	96.7	89.5	87.7	69.8	152	82.3
	B	31	83.7	77.3	70.8	64.4	75	75.8
	C	168	100.0	77.9	72.5	51.2	383	67.9
Effluent	A*	106	50.9	30.2	40.5	18.9	95	70.3
	B*	58	12.0	1.7	6.9	1.7	9	66.6
	C†	169	60.9	7.1	10.7	4.1	266	23.7

*Untreated. †Treated.

tests for B. coli serve as a legitimate quantitative index of pollution, an apparent discrepancy in the scoring of the plant effluents would seem to appear. The explanation for such a discrepancy, however, would seem to the writer to be due to the insufficient number of tubes showing gas in plant B effluent, making its use of little statistical value.

Table 2 offers material for an interesting study of the interrelation of the quality of water and the percentage of presumptive tests confirmed. In this table the percentage column was first arranged in the order as given and the types of water, from which the results were obtained, were then noted opposite each value. The order in which the various characters of water fall is, in four of the

five instances, in agreement with what we should expect from a qualitative judgment of water unsupported by analyses. The assumptions in grading of waters 1, 2, 4, and 5 are borne out by the percentage of tubes confirmed. The position of water 3 (unfiltered, treated) on the same basis of scoring by percentage confirmed, is predetermined and its location is a curious one, establishing as it does the conclusion that an unfiltered treated water is somewhat less polluted, judged by this arbitrary method of scoring, than a filtered water which is not treated. Water 4, as noted in the table, is a mixture of treated filtered and unfiltered water. A qualitative estimate of this type of water would place it in a position between untreated filtered and treated filtered waters. The percentage of tubes confirmed establishes water 4 in such a position, and here again corroborates the accuracy of a method of scoring upon a

TABLE 2

Comparison of condition of water with percentage of tubes confirmed

RATING	CONDITION OF WATER	NUMBER OF TUBES	PER CENT CONFIRMED
1	Raw untreated	610	75.4
2	Filtered untreated	227	68.5
3	Unfiltered treated	37	44.7
4	Mixture of treated filtered and unfiltered	775	24.3
5	Treated filtered	266	23.7

"percentage of confirmatory tests" basis. It is of more than passing interest that water 3 is situated as it is, when we note that its score, 44.7, is almost the exact mathematical mean of the scores of filtered treated and filtered untreated. This would seem to indicate that in the particular waters under discussion the efficiency of filtration about equalled that of disinfection in the removal of the colon bacillus.

After having tested the qualitative estimates of waters by the above system of scoring, it was further elaborated by comparing the scores obtained in Table 2 with a grouping according to total bacterial content. Unfortunately a change in routine analytical determinations, within the periods used by the author, had occurred, which necessitated the use of both 37° and 20°C. counts. The arrangement of the different waters as made in Table 3 seems to be justified, in spite of the lack of adequate total counts of similar

temperature growth, particularly since a transition point was obtained by the fortunate existence of both 20° and 37°C. counts in the case of Water 3. In this table, too, the indications of pollution by the quantity of bacteria are borne out entirely by the percentage of tubes confirmed.

If the percentage of tubes confirmed is a real index of pollution, it would be expected to vary in the same way and with the same

TABLE 3

Relation between average counts and percentage of tubes confirmed

RATING	CONDITION OF WATER	AVERAGE COUNT		PER CENT CONFIRMED
		37°	20°	
1	Raw untreated	18,200		79.1
2	Filtered untreated	570		68.5
3	Mixture of treated unfiltered and treated filtered	45	534	24.3
4	Filtered treated		194	23.7

TABLE 4

Mechanical filter plant; comparison of atmospheric and raw-water conditions

DATE	TEMPERATURE	RAINFALL	PER CENT OF SAMPLES ISOLATED IN 1 CC.	PER CENT TUBES CONFIRMED
1915	*°F.*	*inches*		
October	57.9	2.86	62	61.3
November	45.2	1.48	34	42.3
December	33.5	3.36	67	77.0
1916				
January	38.0	1.36	27	52.5
February	32.6	2.79	38	71.7
March	36.0	3.26	45	56.2
April	51.5	2.69	73	78.4
May	65.2	4.65	69	97.8

degree of sensitiveness as those factors which predetermine it and are, de facto, indicative thereof. Of the factors producing abrupt changes in colon content, none is perhaps relatively more important than the rainfall. It can with justice be assumed that colon content in a general way varies simultaneously with the degree of rainfall. Here, then, we have another basis upon which to test our assumptions of variability of pollution with concomitant variability of confirmation tests for colon. In Table 4 there have been ar-

ranged, for a particular plant A, temperature, rainfall, colon content, and confirmation determinations for a period extending over eight months. With almost no exception, every increase in percentage of tubes confirmed occurs with an increase of total rainfall,

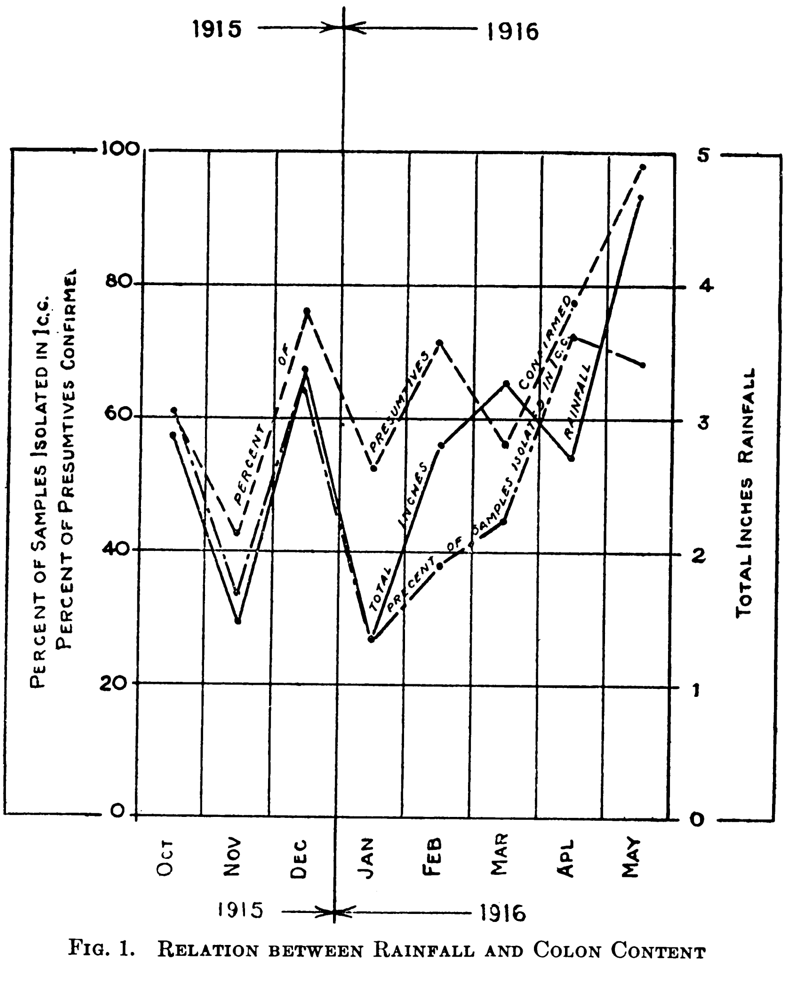

Fig. 1. Relation between Rainfall and Colon Content

and vice versa. A failure of this agreement in April is explained when we observe that during this month the temperature had risen to a large degree, producing a condition of thawing and a consequent increase of colon content. The agreement of the colon con-

tent determinations by isolation in 1 cc. with the rainfall data is not as well defined throughout the period as is that of the percentage of tubes confirmed. In other words, upon this basis, the percentage of tubes confirmed shows a more sensitive effect of rainfall than do the actual colon contents. The results discussed here are shown graphically in the chart.

The conclusions which the above data seem to justify are, that:

1. A water showing the highest degree of actual pollution, as determined by the highest percentage of samples giving a positive isolation test for colon, in general gives the highest percentage of presumptive tests confirmed.

2. A water showing the lowest degree of actual pollution in general gives the lowest percentage of presumptive tests confirmed.

As a result of the above conclusions, a rough quantitative test for pollution, in a general study of a water, might with safety consist only of a determination of the presumptive tests confirmed, rather than of a detailed estimate of the percentage of samples showing isolation tests in varying dilutions. In such a procedure as outlined in the preceding pages, one might establish as bases for comparison a maximum and minimum percentage of tubes confirmed, using for this purpose waters grossly polluted, in the first case, and unquestionably pure in the second. With these maximum and minimum values as standards, the relative position of the water under consideration could be determined with ease by the use of the "percentage of tubes" scoring method.

The use of such a system of scoring as above outlined should, the author believes, bear more intensive study, although the method is of passing interest as an additional indicative factor of water pollution.